

*Investigation of non-uniformity in the charge
collected by individual wires:
Season Gran Finale?*

LArIAT Analysis Summit Meeting
July 29th, 2016

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What I am going to talk about

- Sum up of the wire response to mip charge analysis done on LArIAT Run I data, just before putting the relative technote on DocDB: characteristics of the non uniformity, what it does depend on, what it does not depend on
- Comparison with a data sample from Run II
- Supposedly harmless check of the wire response to charge during Run II data taking period, bringing a last minute plot twist (as in every good season finale)

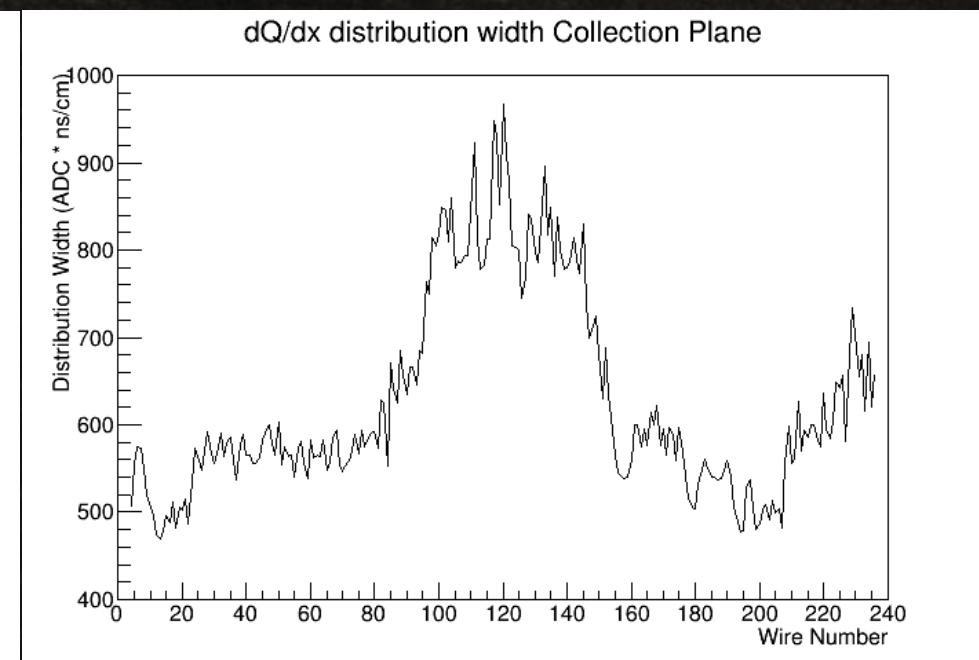
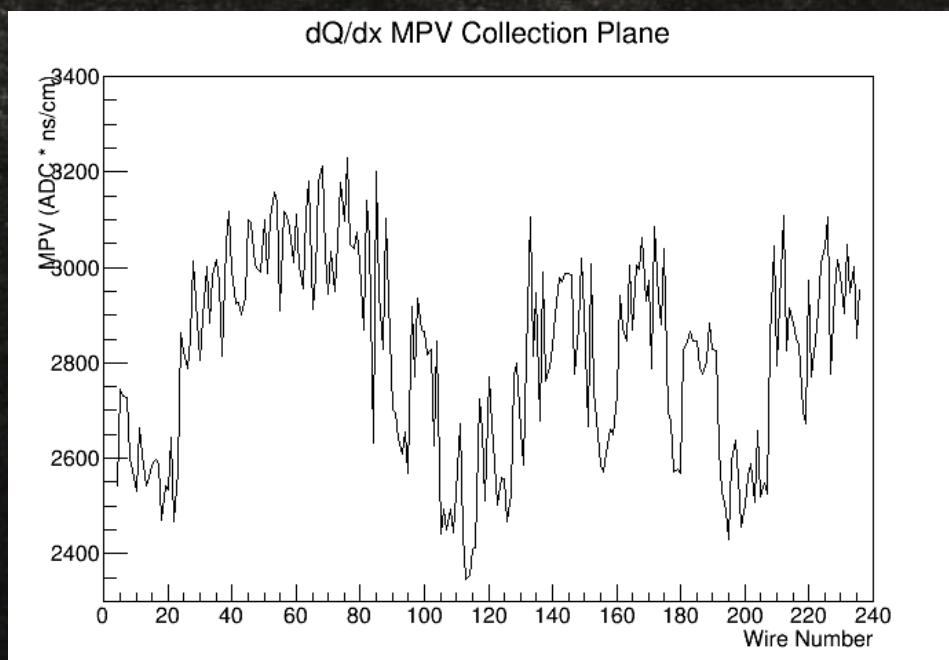
- I'll try to show plots and skip details, leaving them to the tech-note

- To avoid confusion, I'll concentrate on Collection plane only. I did some check of the Induction plane as well and things look more complicated. I leave it to the tech-note

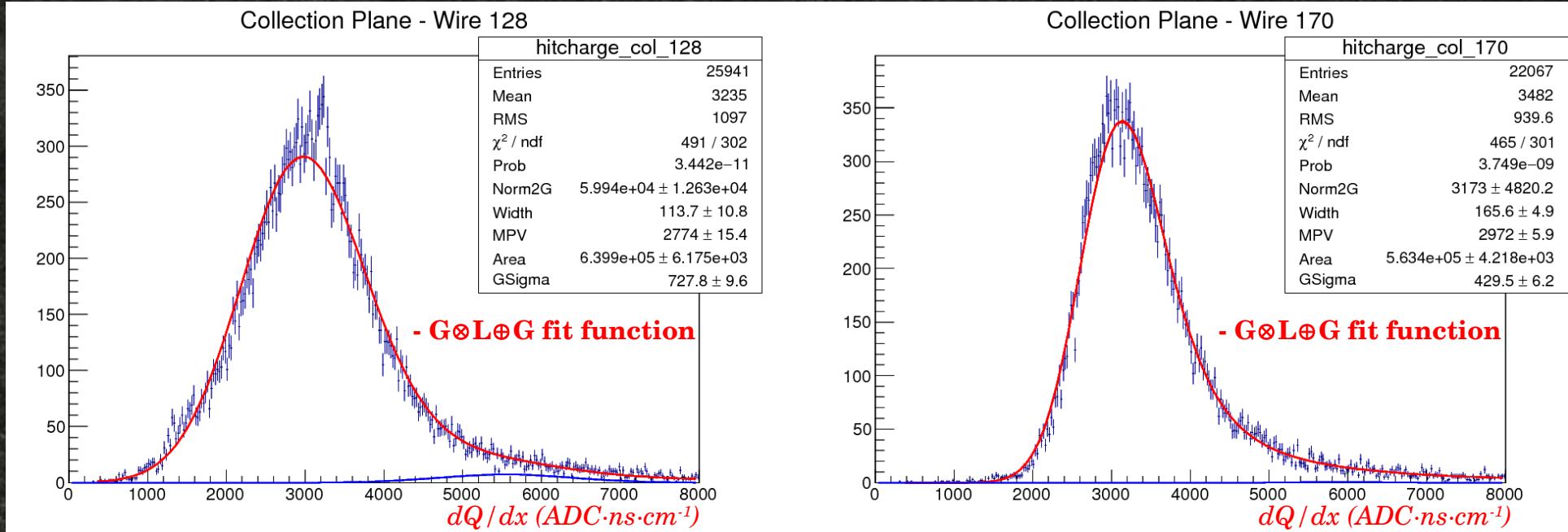
Charge response to mip particles

Data Selection

- ✓ All Run 1 cosmic triggers with standard TPC settings
- ✓ Straight cosmic tracks crossing at least 2 TPC walls
- ✓ Cuts to reject hits belonging to delta rays
- ✓ Hit charge corrected for track inclination and electron lifetime value



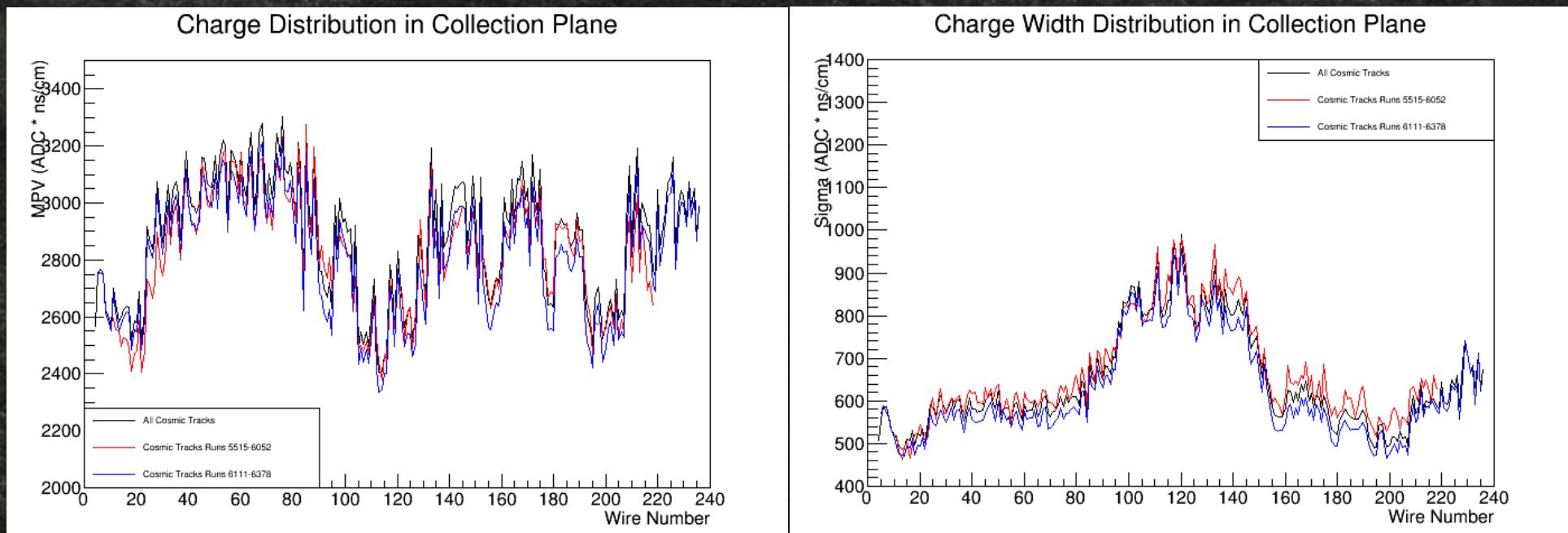
Charge response to mip particles



Non uniformity characteristics

- ✓ dQ/dx MPV change from a group of wires to the neighboring group. Over 20% difference between highest and lowest value
- ✓ The distribution width has a sudden ~50% increase for central wires (~95-150)
- ✓ There is an excess of low dQ/dx hits respect to what expected from a Landau-Gauss distribution. The excess is particularly evident in the central wires (strictly correlated with the distribution enlargement)

Time dependency

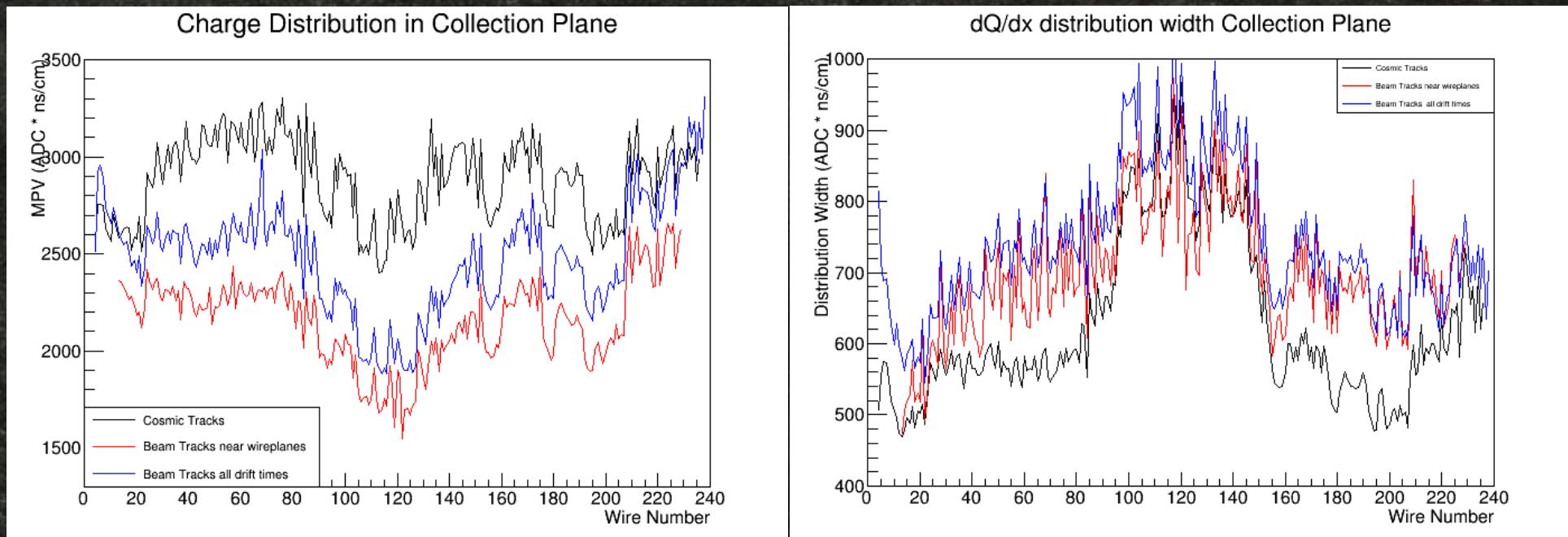


- ✓ Full data sample divided into two subset: early runs and late runs
- ✓ MPV for each wire constant in time

Track topology dependency

- Only cosmic muons are used for the analysis
- To measure dQ/dx MPV for each wire, the electron lifetime needs to be known. To measure the electron lifetime, the response of each wire to mip charge must be known. May this loop, or the selection of only cosmic tracks, be one of the causes of the non-uniformity?
- Analysis repeated with beam tracks in two different ways:
 - Use only beam tracks no more than 5 cm distant from the wireplane → no need to correct for lifetime
 - Use beam tracks covering the whole TPC area → need to correct for lifetime
- Selection of beam instead of cosmic mip done requiring:
 - track vertices within 2 cm from upstream/downstream TPC face (any 2 faces for cosmics)
 - track angle in the YZ plane $70^\circ < \theta < 110^\circ$ ($20^\circ < \theta < 80^\circ$ or $100^\circ < \theta < 160^\circ$ for cosmics)
 - track angle in the ZX plane $0^\circ < \theta < 8^\circ$ ($20^\circ < \theta < 80^\circ$ or $100^\circ < \theta < 160^\circ$ for cosmics)

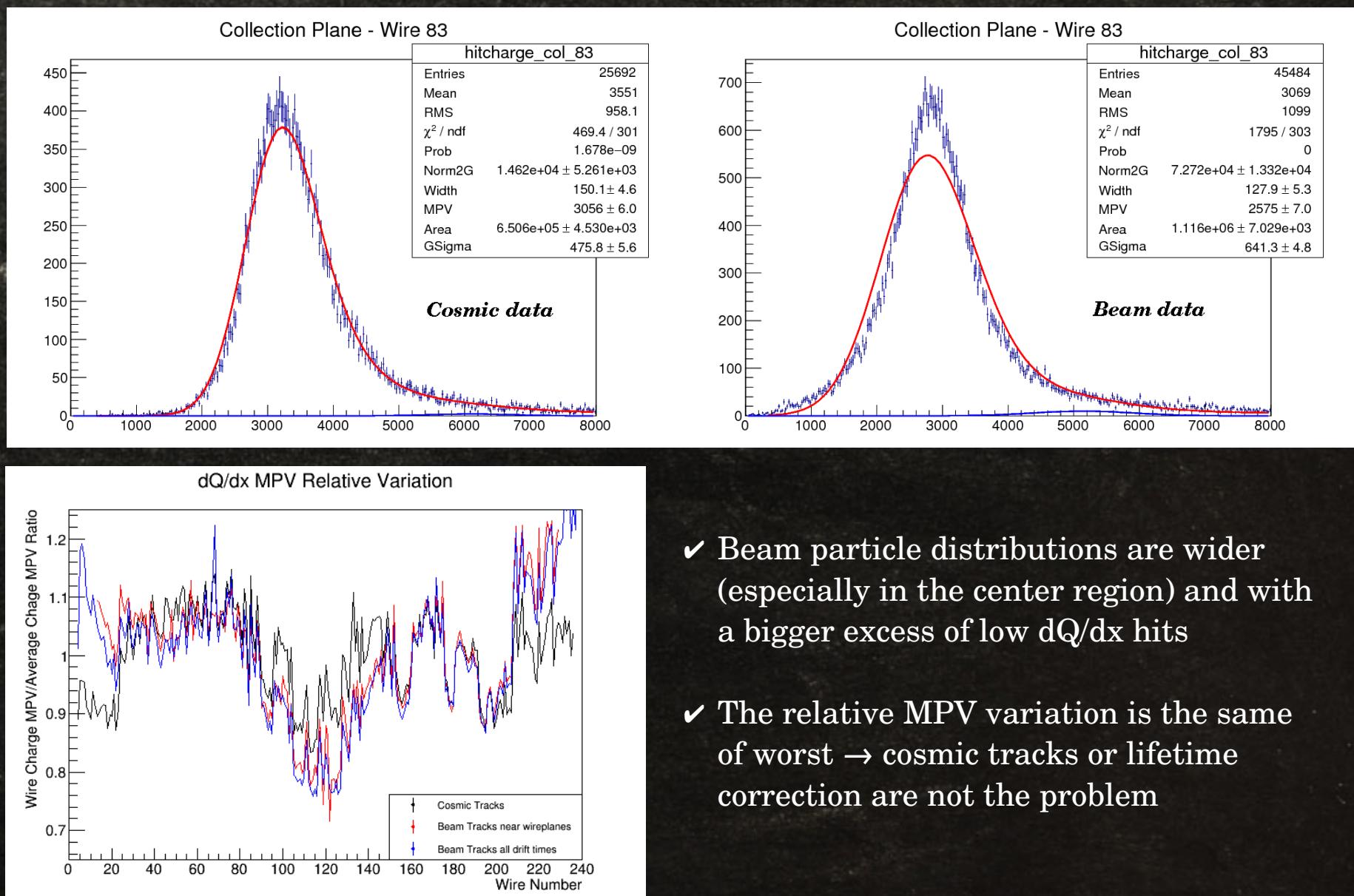
Track topology dependency



Possible explanations of the observed difference:

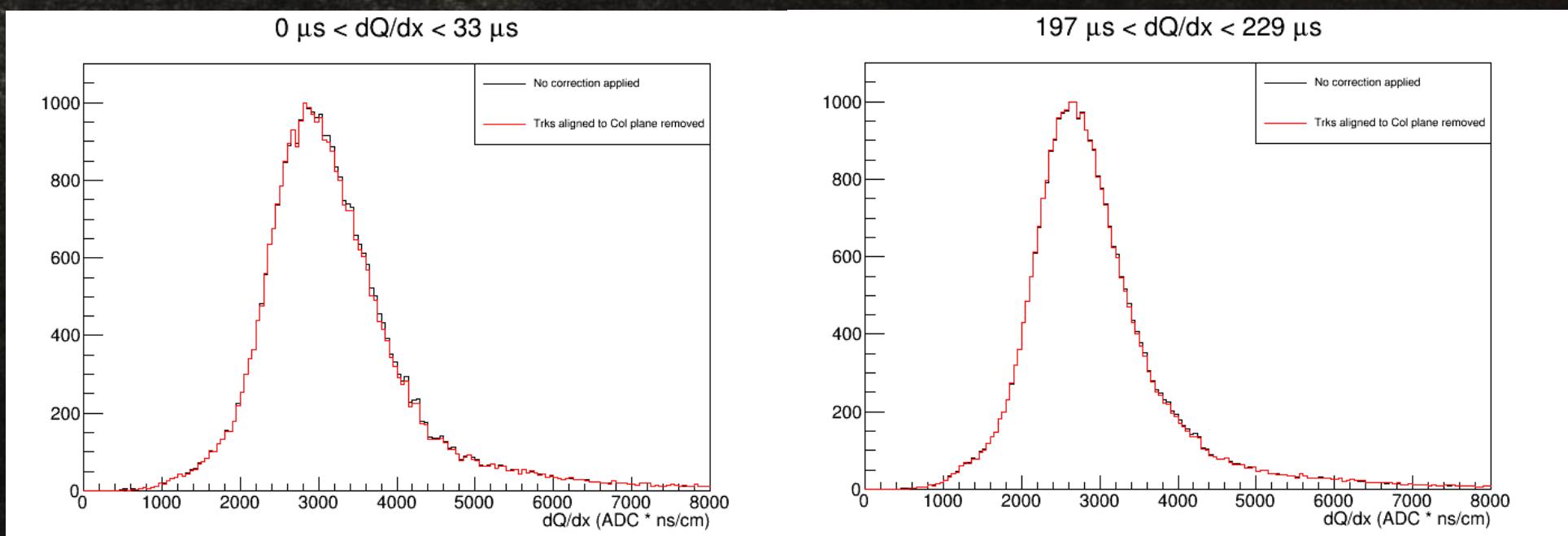
- ✓ Cosmic muons have an average energy of few GeV, where the minimum of the energy loss curve is around 1 GeV → may not be perfectly mip?
- ✓ Electron lifetime values AFTER wire correction are systematically lower than BEFORE wire correction ($\sim 100 \mu\text{s}$) → I may be over-correcting the charge a bit
- ✓ Beam particles not really muons?

Track topology dependency

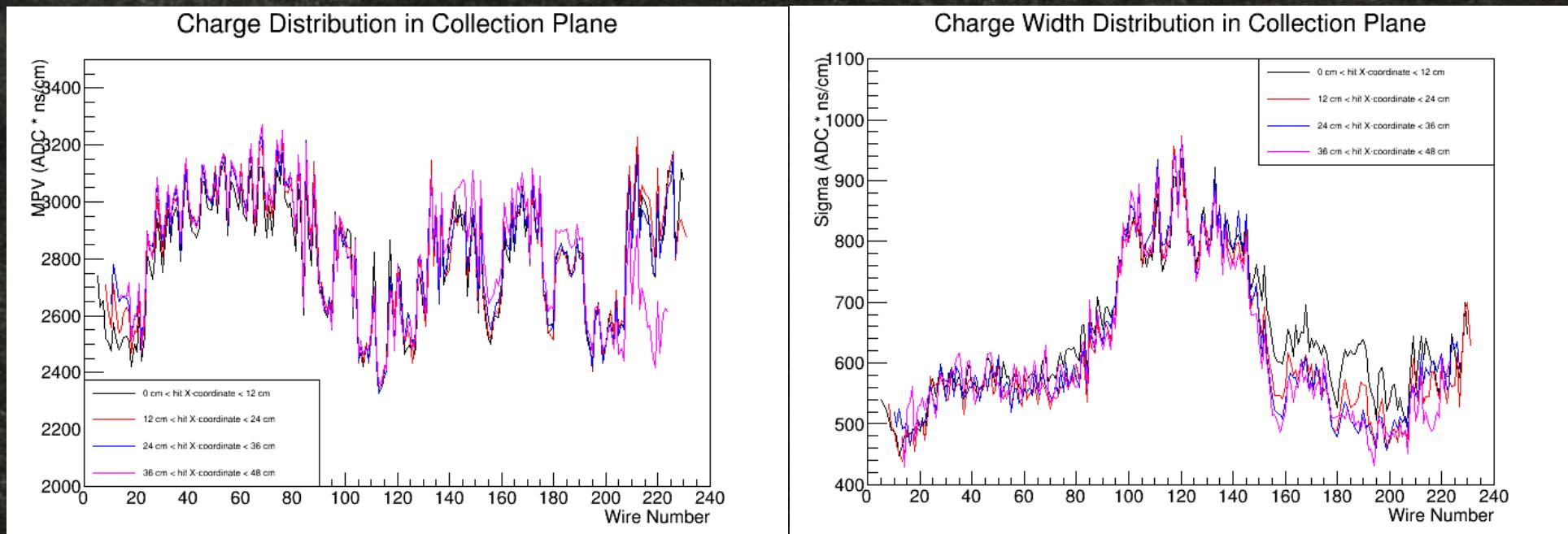


Track-Wire angle dependency

- ✓ Elena found in the dE/dx distribution low energy hits belonging to tracks aligned to Collection plane wires (DocDB 1876-v2)
- ✓ Hypothesis tested comparing dQ/dx distributions in drift time bins with/without tracks aligned to Collection plane wires
- ✓ No difference found. Selected cosmic tracks cross all or most of the drift time – charge from the track arrives at the wires over hundreds of microseconds

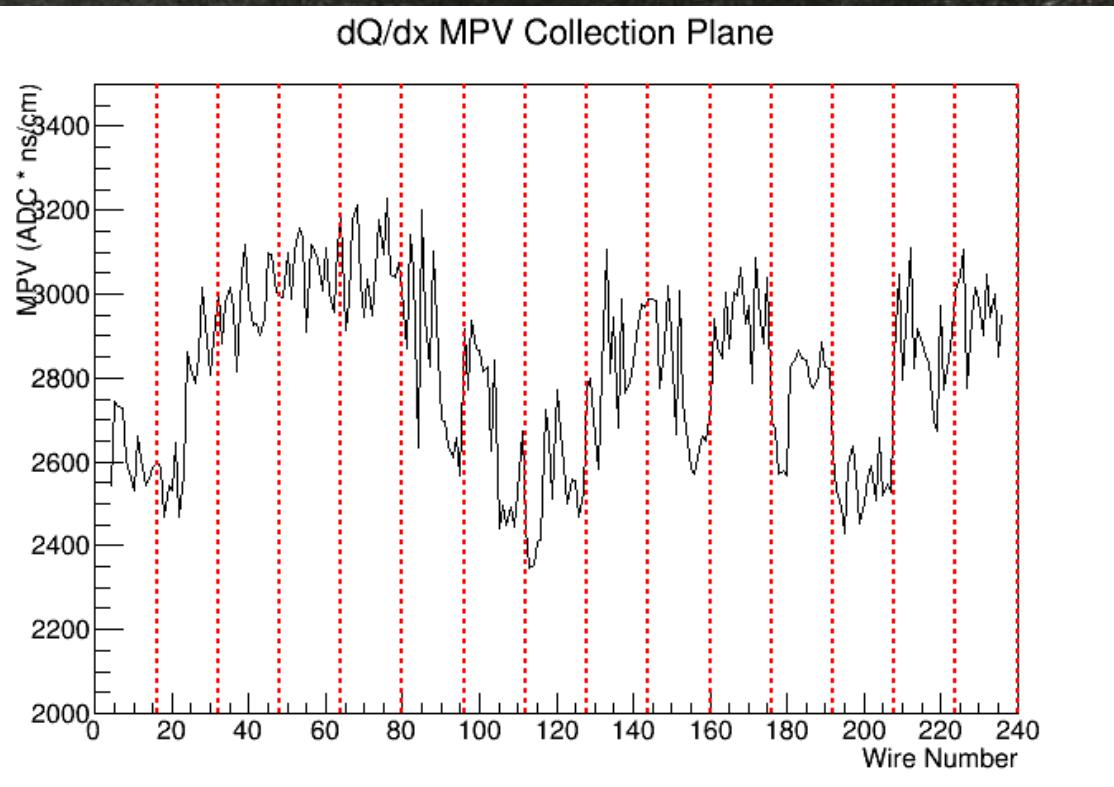


X-coordinate position dependency



- ✓ X coordinate (drift time) divided in 4 equal bins
- ✓ Analysis repeated selecting each time only hits falling in a specific bin
- ✓ No dependency from X coordinate position observed

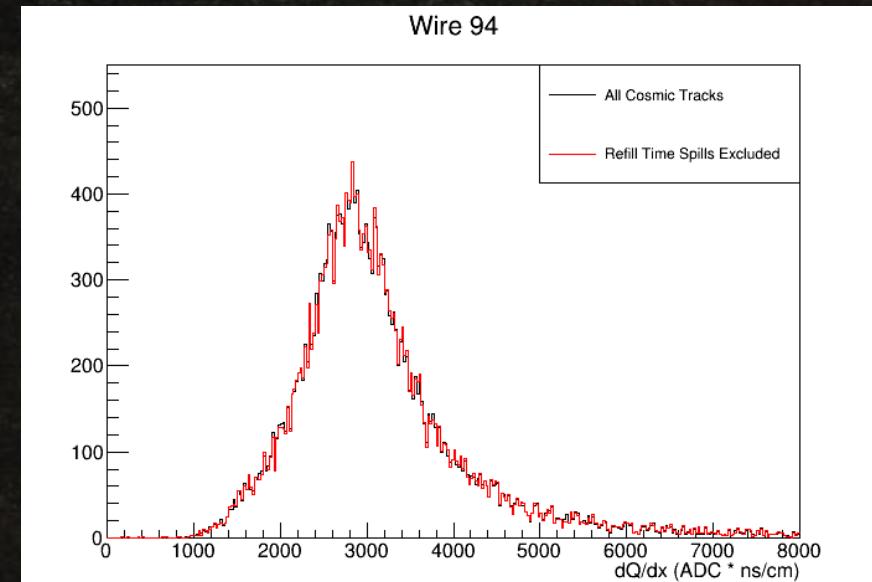
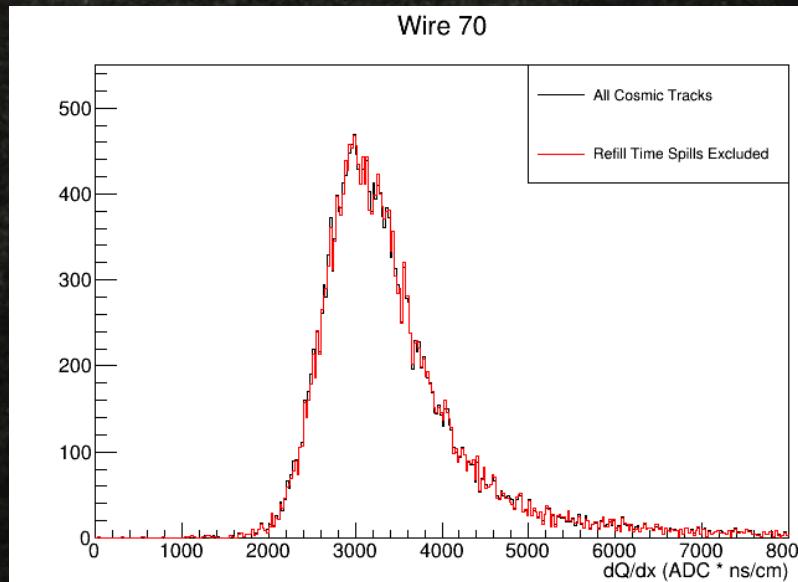
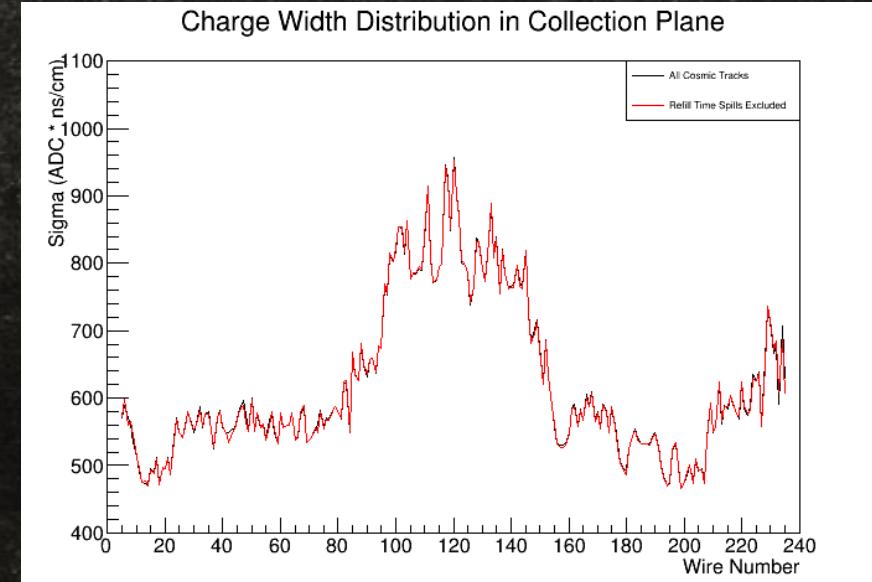
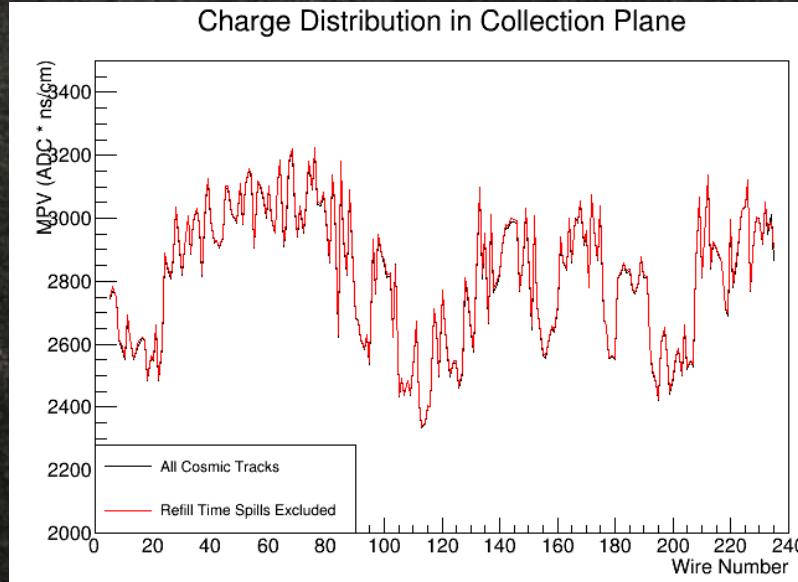
Cold Electronics dependency



- ✓ Red lines represent ASICs boundaries
- ✓ 1 ASIC connected to 16 channels
- ✓ 3 ASICs connected to each motherboard, powered by a single Warm Receiver Card
- ✓ 4 ASICs per D2S card and CAEN digitizer

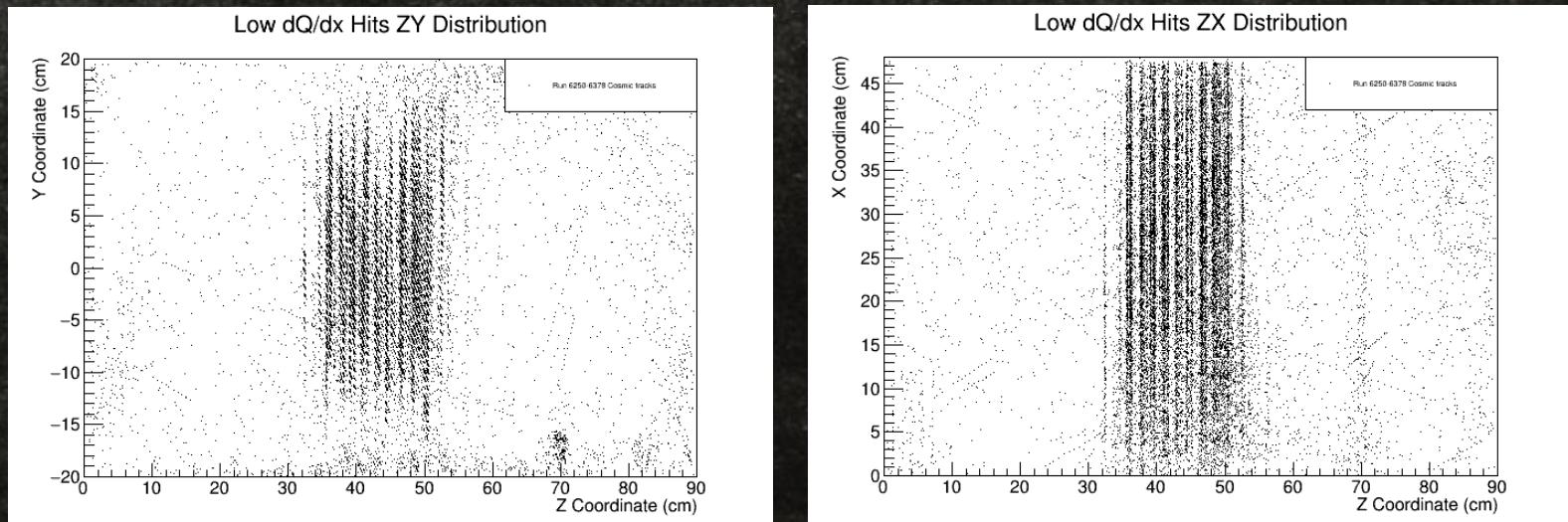
Neither the single ASICs nor any of the mentioned combinations consistently align with the features of the MPV variations

Cryostat refill-induced noise dependency



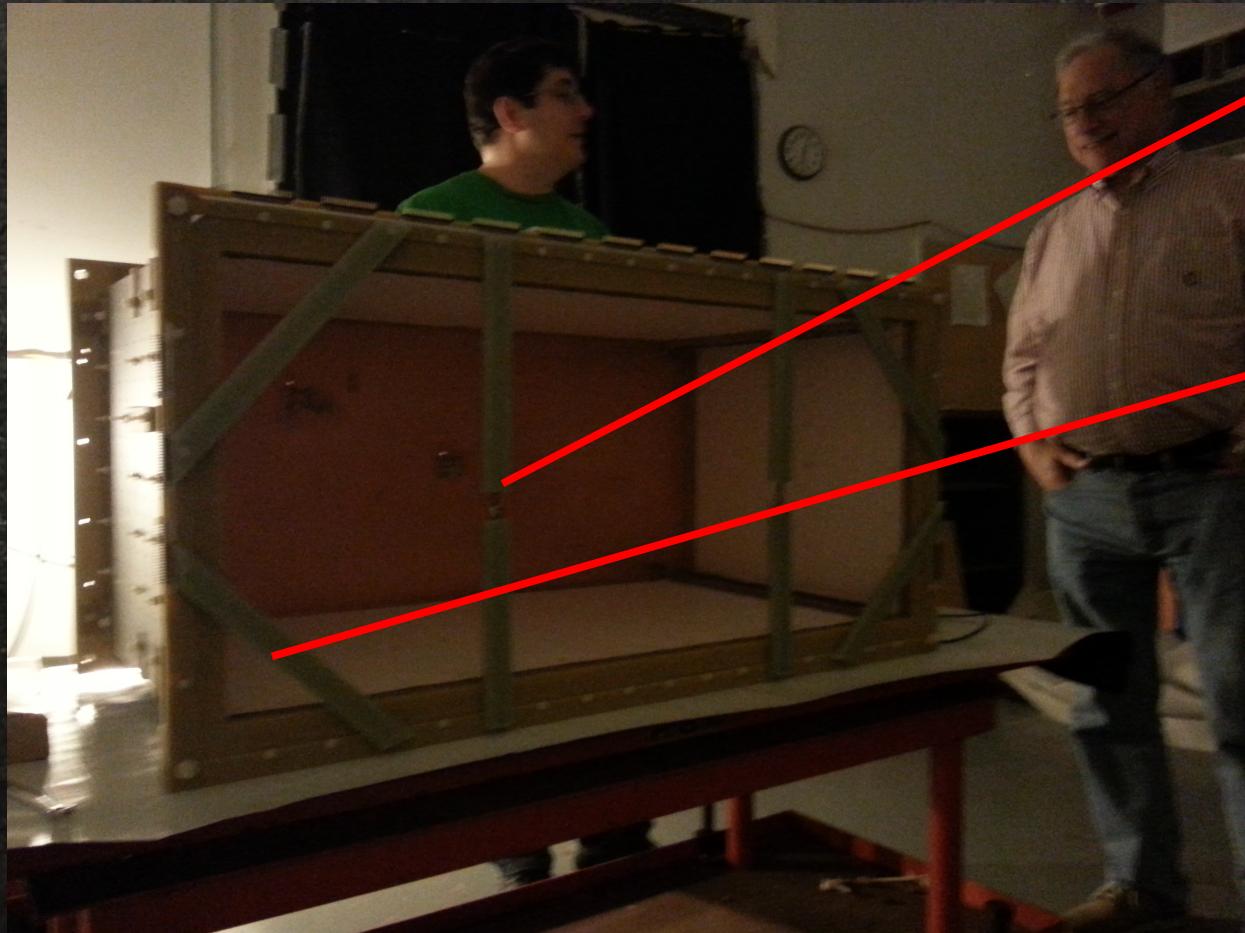
Low dQ/dx hits excess

Distribution inside the TPC and along the wireplane of hits with lifetime-corrected charge $dQ/dx < 1600$ ($ADC \cdot ns/cm$) for all runs between 6250 and 6378 with lifetime $1.5\ ms < \tau < 1.9\ ms$



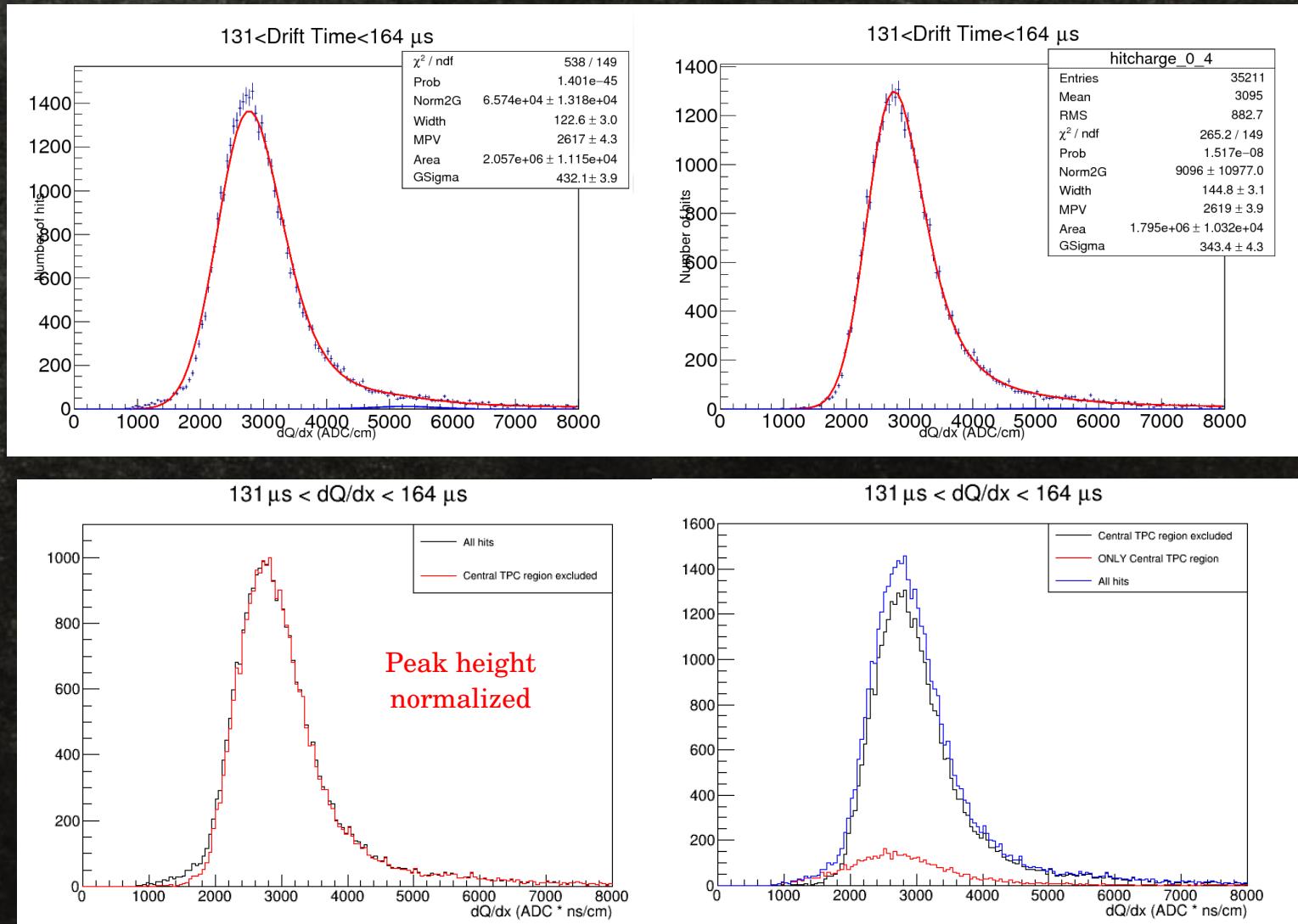
- ✓ Low charge hits concentrated in a box $0\ cm < X < 47\ cm$; $-17\ cm < Y < 17\ cm$; $30\ cm < Z < 56\ cm$
- ✓ Potentially due to a combination of PMTs negative polarity and Shield plane loss of tension (the latter in particular would explain the “stripe” feature)

Low dQ/dx hits excess: origin hypothesis



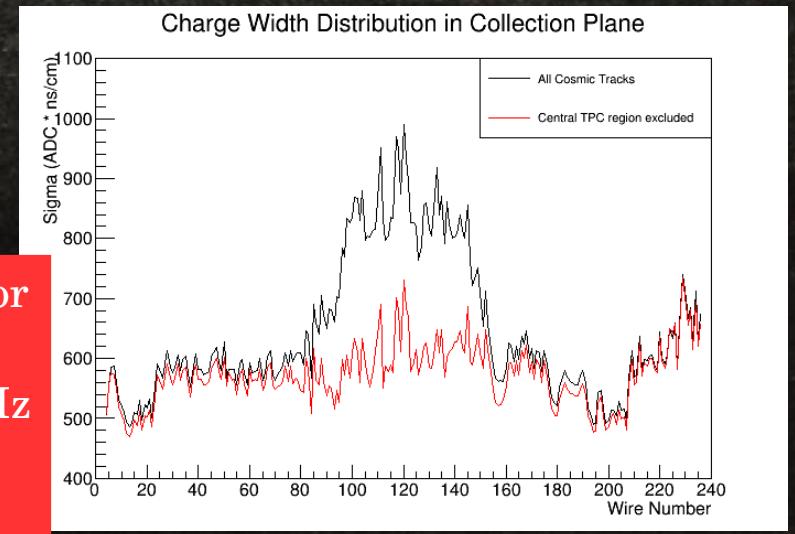
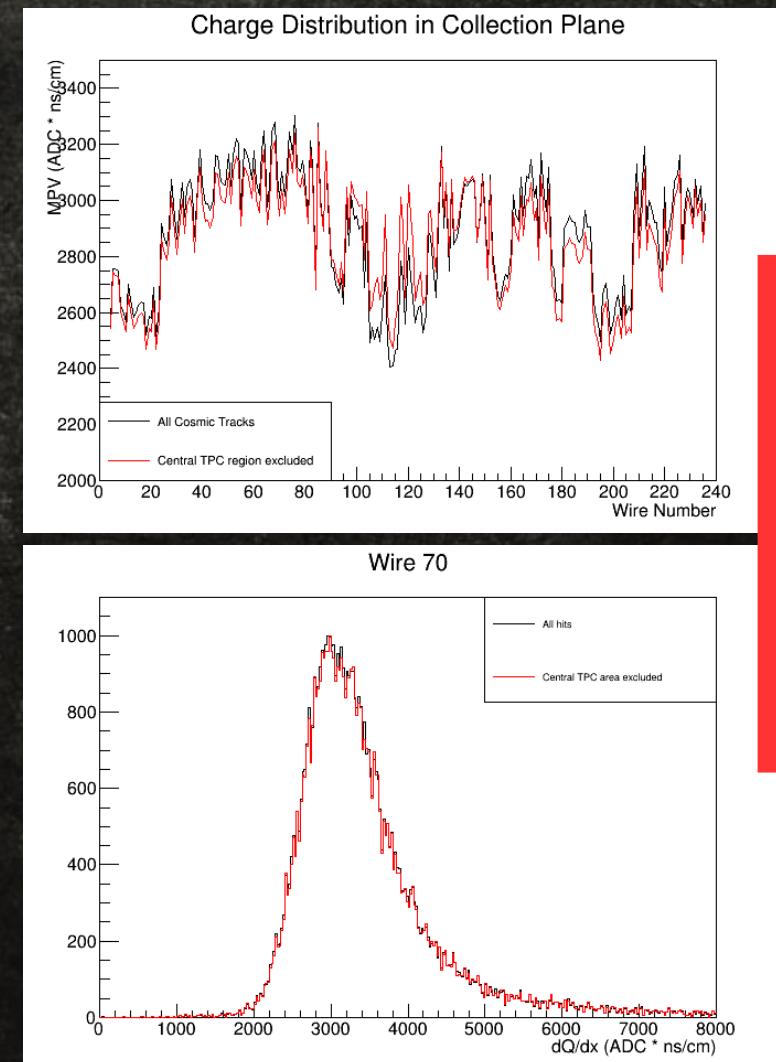
- ✓ Tension guaranteed by the friction generated by the G10 threads pushing against the steel threads
- ✓ If G10 threads gets slightly eroded, the G10 bars will slowly move towards each other. The fixed-size G10 bars at the corners would give extra support to the sides of the wireplane, but not to the central part

Removing central TPC area from dQ/dx distributions: lifetime analysis

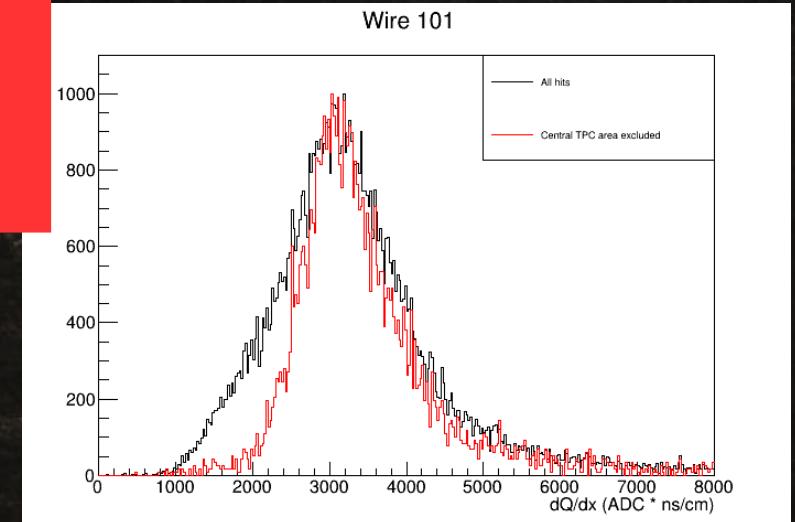
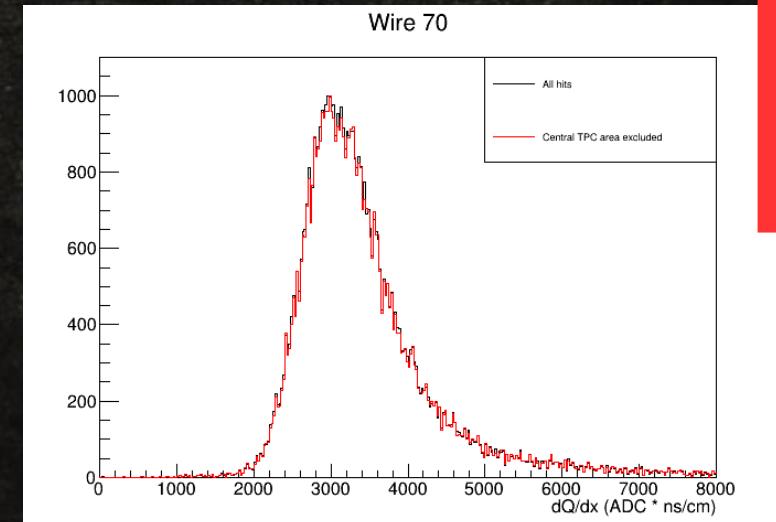


Run 6374-6378
 τ changes from
 $\tau = 1744 \mu\text{s}$
 to
 $\tau = 1841 \mu\text{s}$

Removing central TPC area from dQ/dx distributions: wire analysis

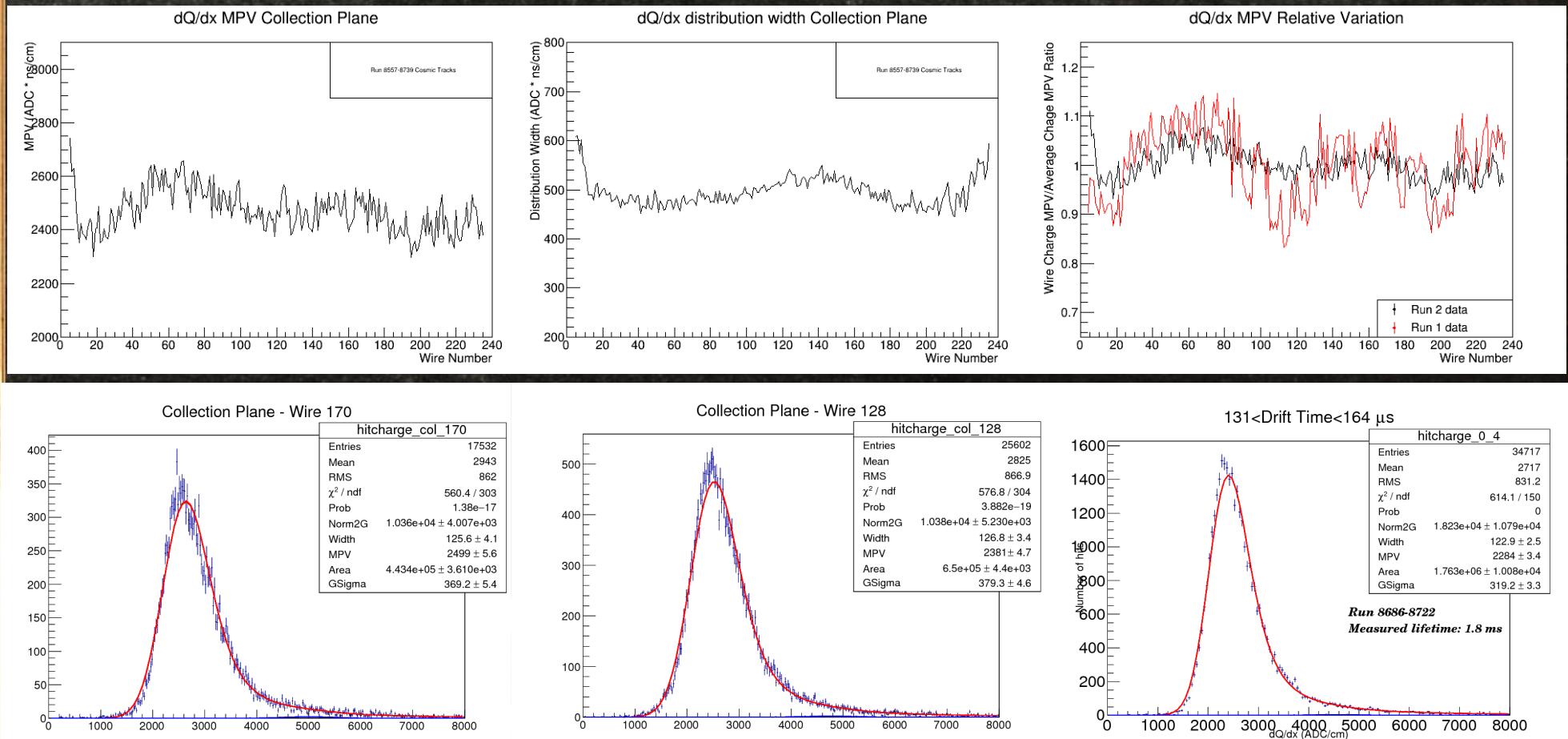


Best hypothesis for
 dQ/dx MPV
variation: 200 MHz
noise picked
up/generated by
the feedback
capacitors of the
WRD amplifier
channels



Comparison to Run II data sample

Run II data

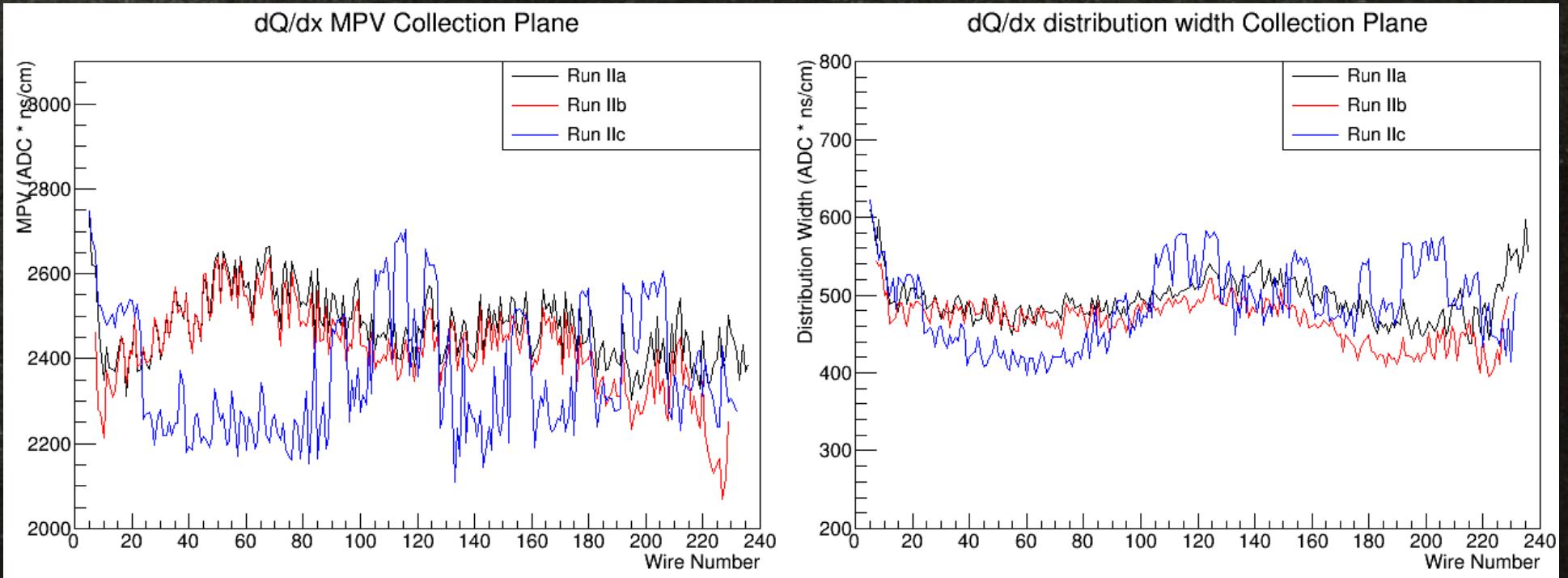


Between Run I and Run II PMTs polarity changed from negative to positive, Shield Plane wires tensioned, WRD feedback capacitor removed (and so the 200 MHz noise). Both MPV variation and low dQ/dx hit excess greatly reduced

Gran Finale Plot Twist!

- Decided to check wire response to charge during Run II, to verify whether an eventual new loss of tension in the Shield Plane would appear as an increase of low dQ/dx hits
- Defined three data samples:
 - **Run IIa:** data at the beginning of Run II, from end of February to mid-March
 - **Run IIb:** ~10 days of data immediately after first filter regeneration (cryostat fully emptied and opened)
 - **Run IIc:** ~10 days of data immediately after second filter regeneration (cryostat only partially emptied, not warmed up)
- I found something... but not what I was expecting

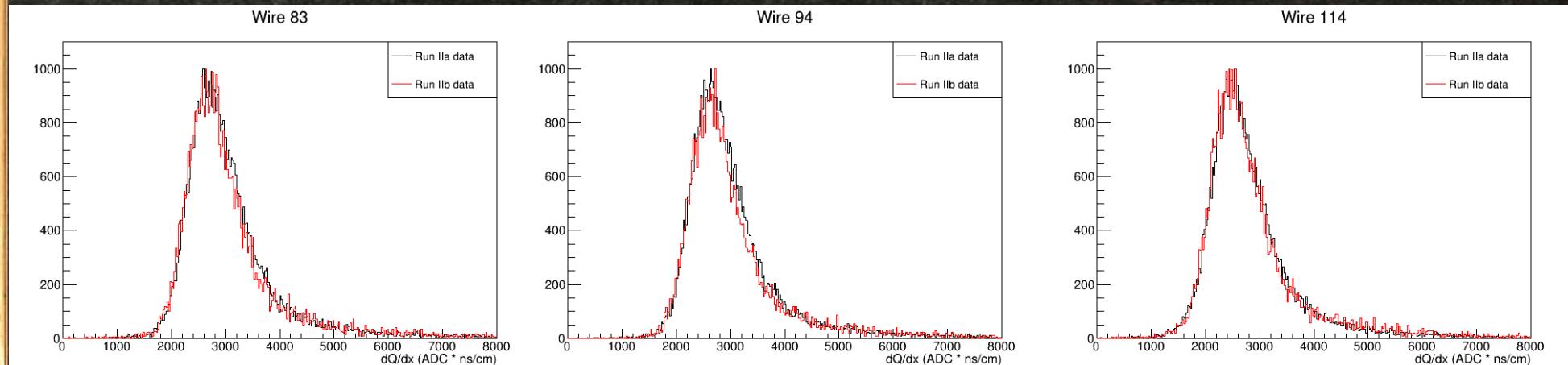
dQ/dx MPV and sigma: Run IIa vs IIb vs IIc



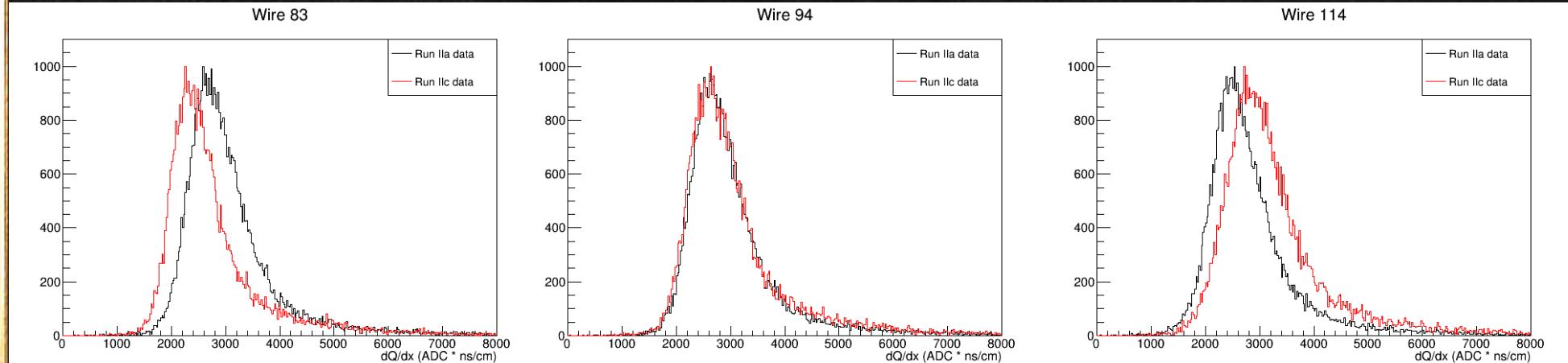
No difference between Run IIa and IIb. What happened in Run IIc???

Single Wire distributions

Run IIa vs IIb

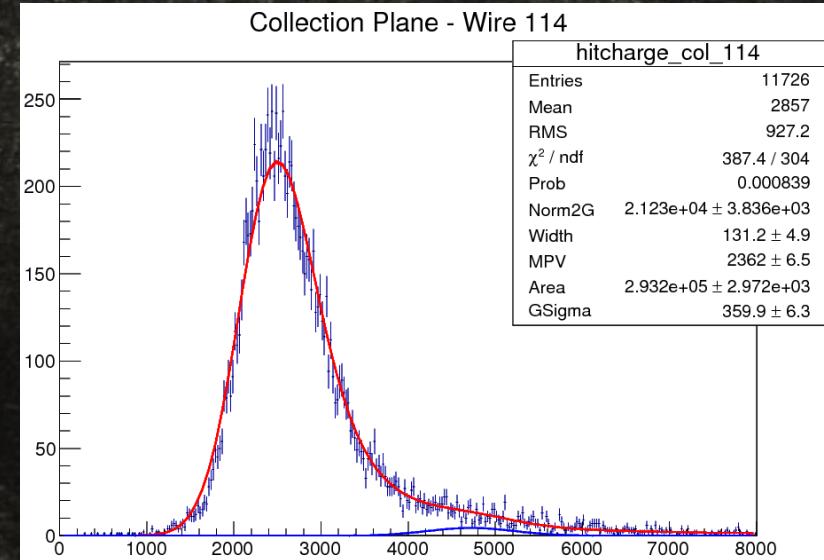
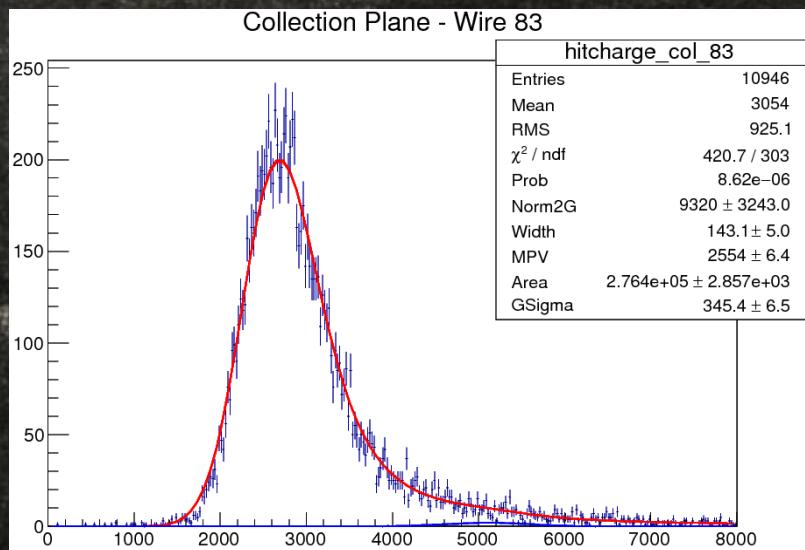


Run IIa vs IIc

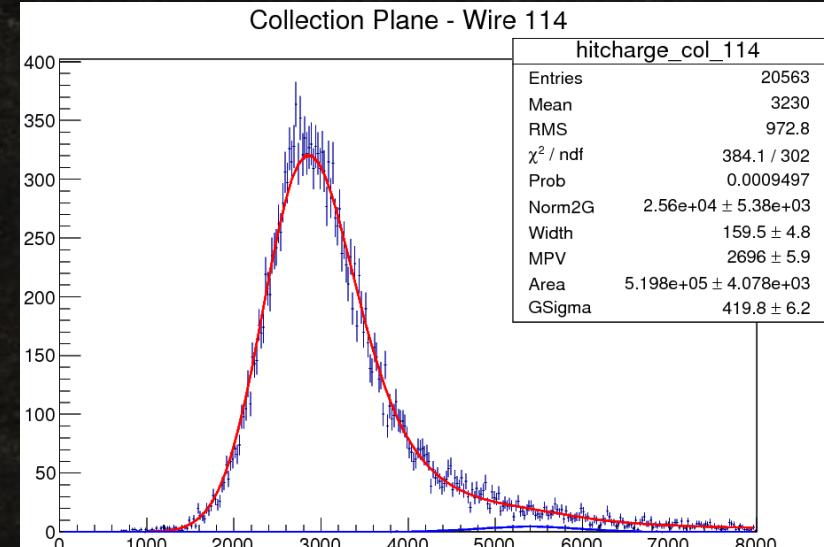
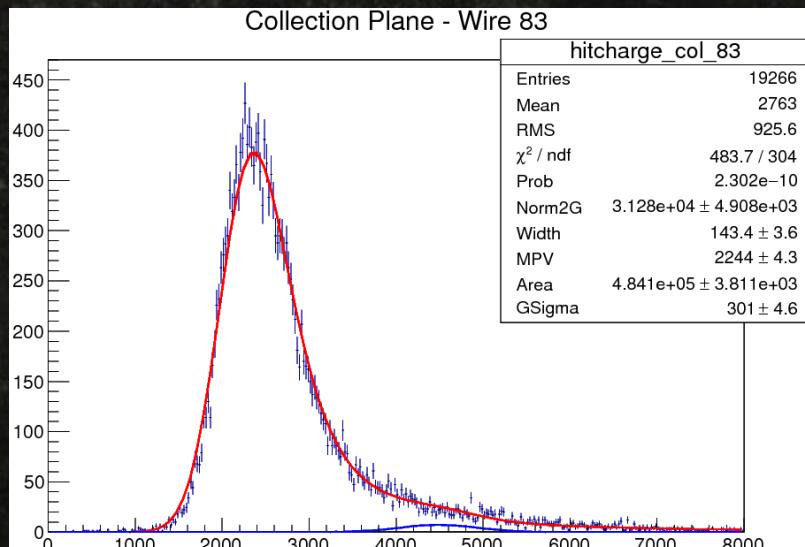


Wire distribution Fit: Run IIb vs Run IIc

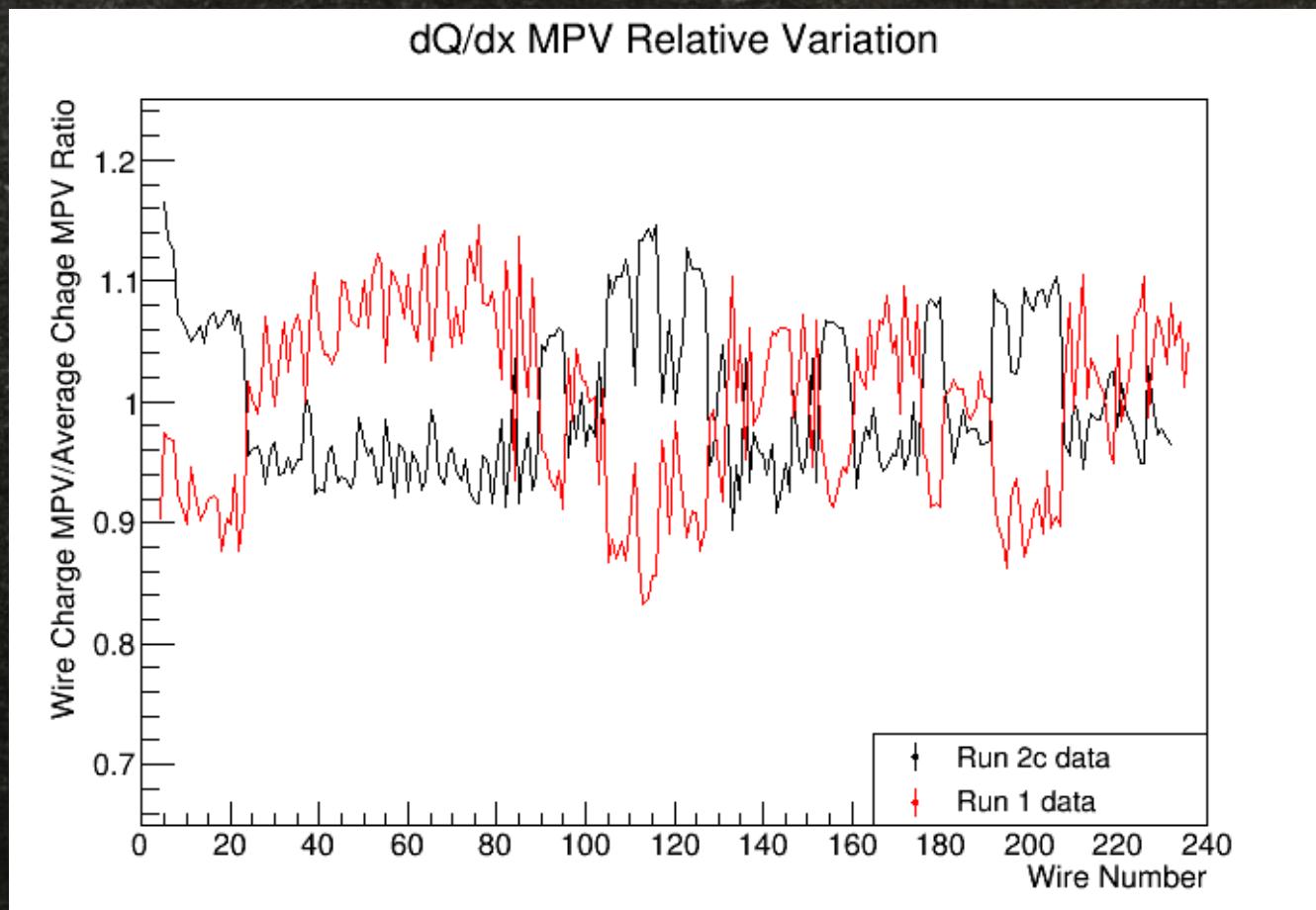
Run IIb



Run IIc



Correction Factor: Run IIc vs Run I



The MPV variation is inverted respect to RunI. I don't have a good explanation to that (maybe I'm plotting two inverted things).

Best I can do is two sets of charge corrections for Run II, for before and after the second filter regeneration